13.—The Geology of the North-Eastern Margin of the Fitzroy Basin between Hawkstone Creek and Oscar Range, Western Australia

By J. Rade*

Manuscript received—22nd February, 1961

The area described in this paper includes part of the north-eastern margin of the Fitzroy Basin and stretches from long. 124° 30′ E. to 125° 10′ E. The sedimentary strata in the area consist of: Pleistocene to Recent deposits; Permian Grant Formation; Lower Carboniferous Laurel Beds; Upper Devonian Fairfield Beds, Napier Formation, Van Emmerick Conglomerate and Behn Conglomerate; and Middle Devonian Pillara Formation. The middle part of the western portion is occupied by a syncline whose axis trends north-west. The south-western corner of the area is occupied by the north-eastern slopes of a buried ridge which is the north-western continuation of the Oscar Range. The area exhibits strong faulting and fracturing, the main faults trending approximately parallel to the Napier Range.

Introduction

The area described below includes part of the north-eastern margin of the Fitzroy Basin and stretches from long. 124° 30′ E. to 125° 10′ E. The emphasis in this paper is on elucidation of stratigraphy and structure, with special reference to the Upper Devonian Fairfield Beds and the Lower Carboniferous Laurel Beds.

Stratigraphy

The sedimentary strata consist of: Pleistocene to Recent deposits; Permian Grant Formation; Lower Carboniferous Laurel Beds; Upper Devonian Fairfield Beds, Napier Formation, Van Emmerick Conglomerate and Behn Conglomerate; and Middle Devonian Pillara Formation.

The average thicknesses of the strata are as follows:

Pleistocene to Recent—0-100 feet.
Permian Grant Formation—700 feet.
Lower Carboniferous Laurel Beds—1,300 feet.
Upper Devonian Fairfield Beds—1,500 feet.
Napier Formation—1,500 feet.

Pleistocene to Recent

Pleistocene to Recent deposits are alluvium, sand, gravel, and travertine. The largest rivers, such as the Lennard and Barker Rivers, have scored deep valleys in the marls, shales, siltstones and calcarenites of the Upper Devonian Fairfield Beds and the Lower Carboniferous Laurel Beds, and these valleys are now filled with alluvium, mostly sand, gravel, and some silt. Sand and gravel are also usual on the areas underlain by the Permian Grant Formation, and represent its disintegration products. Much silt, fine sand, and clayey silt and sand are deposited on the plains underlain by Upper Devonian Fairfield Beds and Lower Carboniferous Laurel Beds.

* Box 28a, 601 St. Kilda Road, Melbourne, Victoria.

Permian

Grant Formation.—The Grant Formation consists of brown to white, fine- to medium-grained sandstone, which is often cross-bedded. The sandstone contains lenses of rounded to subrounded pebbles as well as scattered pebbles and gritty layers. The average thickness of the pebble lenses is 1 foot, and the pebbles in them, which are mostly quartzite, range in size from $\frac{1}{4}$ inch to 4 inches. Very often the sandstones of the Grant Formation contain clay pellets.

Some sandstones of this formation are flaggy, with the flags from 1 to 5 inches thick. Some flaggy brown ferruginous shaley sandstone is also encountered in the exposures of Grant Formation at the south-western corner of the area mapped. The thickness of the flags in this shaley sandstone is from $\frac{1}{4}$ to $1\frac{1}{2}$ inches.

In the west of the area the Grant Formation varies in thickness from approximately 700 to 1,500 feet.

The author thinks that the deposition of sandstones on the Lennard Shelf to which a Grant Formation age is assigned, may have commenced in Carboniferous times and continued into the Permian. These Lennard Shelf sandstones represent marginal deposits of the Fitzroy Basin. The unit underlying the Grant Formation in Grant Range No. 1 and Fraser River No. 1 bores, has been named the Anderson Formation and assigned an Upper Carboniferous age (McWhae, Playford, Lindner, Glenister and Balme 1958, p. 50). The author considers that the lower portion of the deposits of the Grant Formation exposed in the area mapped probably corresponds to the Upper Carboniferous Anderson Formation which is encountered in the deeper parts of the Fitzroy Basin. The latter formation consists mostly of reddish brown shales and white sandstones. Reddish brown shales crop out along the Station Creek Fault at Station Creek, where they are upturned vertically by drag along the surface expression of the fault. If the lower part of the Grant Formation on the Lennard Shelf does belong to the Upper Carboniferous, then the deposition of these sediments in the Fitzroy Basin can be correlated better with the corresponding deposition in the Bonaparte Gulf Basin.

Lower Carboniferous

Laurel Beds.—The Lower Carboniferous Laurel Beds are exposed in the area mapped as shown by fossils and lithology. Species of *Productus* were found at Mt. Percy in the eastern part of the area and are identical with species found south-west of the Oscar Range at Laurel Downs,

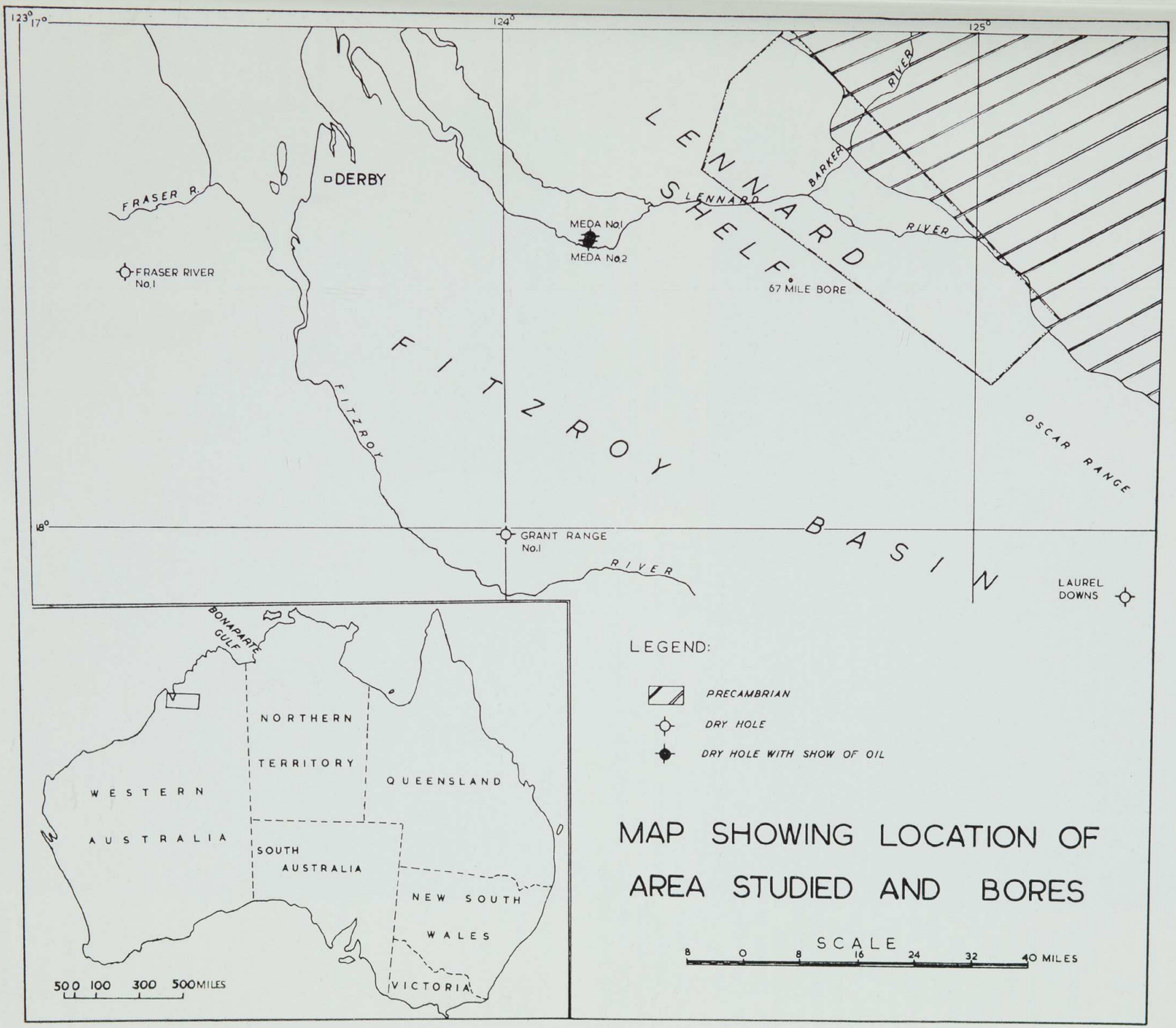

123°
17°
124°
125°
DERBY
FRASER R.
FRASER RIVER No.1
MEDA No.1
MEDA No.2
LENNARD SHELF
LENNARD RIVER
BARKER RIVER
67 MILE BORE
FITZROY BASIN
FITZROY
OSCAR RANGE
18°
GRANT RANGE No.1
LAUREL DOWNS
BONAPARTE GULF
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA
500 100 300 500 MILES
LEGEND:
PRECAMBRIAN
DRY HOLE
DRY HOLE WITH SHOW OF OIL
MAP SHOWING LOCATION OF AREA STUDIED AND BORES
SCALE
8 0 8 16 24 32 40 MILES

Fig. 1.

the type area of the Laurel Beds in the Fitzroy Basin. The boundary of the Laurel Beds can be distinguished fairly exactly in the mapped area. A characteristic marker bed with *Cyrtospirifer* occurs in the upper part of the Upper Devonian Fairfield Beds at Station Creek, north of Mt. Percy, and at the Lennard River 6½ miles west of Windjana Gorge. The first appearance of the overlying Laurel Beds can be estimated relative to this marker bed. For this reason, the Laurel Beds have also been identified at the lower part of Mt. North Creek.

Slump-folding is characteristic of the Laurel Beds and is widely encountered at Station Creek and to the north of Mt. Percy. It will be described below in the section on folding.

The calcarenitic facies of the Laurel Beds exposed north-north-west of Mt. Percy, close to the contact with the Grant Formation, resembles the upper layers of the Septimus Limestone on Mt. Septimus, in the Bonaparte Gulf Basin. The occurrence of many small crinoid stems in both localities is also striking, as is the appearance of *Camarotoechia* horizons. *Camarotoechia pleurodon* var. *tripla* Prendergast has accumulated in layers in the Laurel Beds at Station Creek, in the western part of the area mapped.

Guppy, Lindner, Rattigan and Casey (1958, p. 41) have recorded that a stratigraphic bore drilled near Laurel Downs penetrated 1,400 feet of marine, fossiliferous Laurel Beds. In the south-western corner of the area mapped the Laurel Beds are estimated to be approximately 1,300 feet thick.

Upper Devonian

Fairfield Beds.—The Upper Devonian Fairfield Beds consist of shales, marls, claystone, some siltstone and calcarenite. The bulk of the Fairfield Beds is made up of shales with thin calcarenite and a few siltstone intercalations. In the upper part, the intercalations are from 2 to 12 feet thick, though a calcarenite intercalation 16 feet thick is occasionally met, as in the Station Creek area.

Much larger thicknesses of calcarenite occur in the lower portion of the Fairfield Beds in the eastern part of the area investigated. There is a typical exposure of Fairfield Beds one mile north-east of Fairfield homestead. Two outcrops were encountered in this locality, at the foot of Napier Range where calcarenites of the Napier Formation are exposed and they represent the basal layers of the Fairfield Beds. These outcrops more or less resemble in lithology the outcrops of the upper part of the Napier Formation exposed on the western margin of Napier Range, 4 miles north-north-east of Old Napier Ruins. In the latter, the strata represent the transitional stage from Napier Formation to Fairfield Beds.

Upper Devonian Fairfield Beds exposed north-east of Mt. Percy consist mainly of shales with intercalated calcarenites. The shales, as usual for this type of sediment, form very poor exposures and it is likely that the areas between calcarenite exposures are commonly occupied by shales. The thickness of calcarenitic intercalations ranges from 6 to 10 feet. Thin layers of siltstone are occasionally present between the shales and marls. The Fairfield Beds exposed in the southern channel of the Lennard River 6½ miles west of Windjana Gorge consist mostly of shales, containing intercalations of clayey siltstone, clayey calcareous sandstone and sandy calcarenite. These intercalations are thin in comparison with the shale layers which vary from 60 to 120 feet in thickness. The shale itself often contains layers of brownish grey siltstone 0.5-1 inch thick.

To the east of the Barker River, 4½ miles south-east of Napier Downs, greenish grey shales, grey calcarenites and sandy calcarenites of the Fairfield Beds are very poorly exposed. Shales predominate and the calcarenitic intercalations are thin, from 1 to 4 feet. The calcarenites are often flaggy, the average thickness of the flags being 1-3 inches.

The Fairfield Beds crop out weakly ½ mile and 2½ miles north-west of Old Napier Ruins where they consist of greenish grey shales and silty shales, with thin layers of yellowish grey calcarenite.

It is clear that Fairfield Beds are mostly shaley in the area north-west of Old Napier Ruins where a shale layer more than 400 feet thick was encountered. Shales and marls of considerable thickness contain grey sandy calcarenite layers which are very thin by comparison and vary from 1 foot 6 inches to 16 feet in thickness. However, some of these calcarenites are very fossiliferous, containing large populations of *Camarotoechia* and *Cyrtospirifer*.

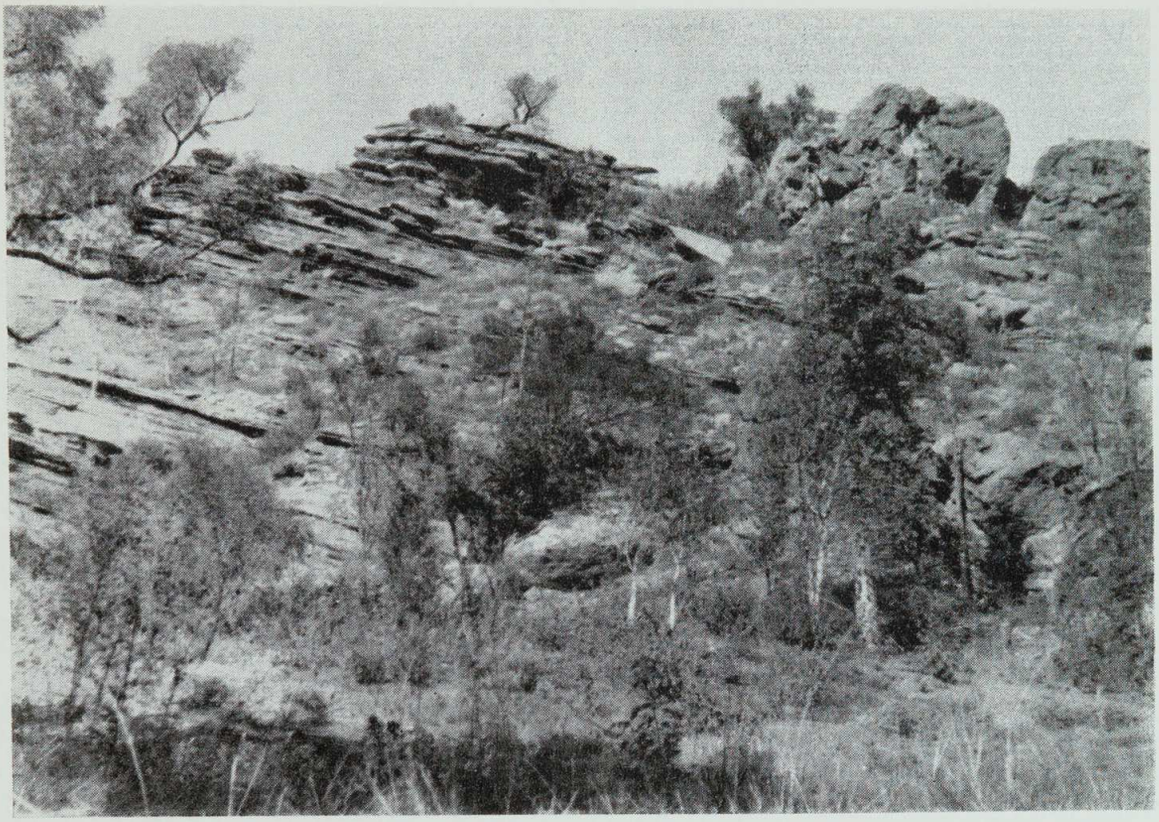
A characteristic fossiliferous calcarenite horizon is located on Sation Creek, 2½ miles west of Old Napier Ruins. Underlain by shaley marl, it contains great numbers of *Cyrtospirifer*, and can be used as a marker bed as described above.

The total thickness of the Fairfield Beds in this area is estimated at approximately 1,500 feet.

Napier Formation.—The Upper Devonian is represented by the Fairfield Beds and the Napier Formation in the western part of the area under consideration. The Fairfield Beds, shown above, are mostly of shale, and calcarenitic intercalations there are subordinate. By contrast, the Napier Formation is mostly calcarenite with bioherms. Some sandy limestone also occurs. The upper part of the Napier Formation is composed of reef limestones and dolomites which are exposed in Windjana Gorge and 6 miles north-north-west of Old Napier Ruins. Small reefs are also encountered in the exposures of Napier Formation elsewhere in the western part of the mapped area. Bioherms of the Napier Formation in Napier Range, 3½ miles north-north-east of Old Napier Ruins average 400 feet by 200 feet in size. Off-reef dips average about 25°. The small reefs are more or less interconnected and so form a string of reefs along the strike of the strata. This characteristic feature may be important when considering the reefs as possible reservoir rocks for oil accumulation.

In Wombarella Gap, approximately 682 feet of Napier Formation strata are exposed, and in Barker Gorge, approximately 1,142 feet. Red calcareous sandstone constitutes the lower part of the exposure whereas the upper part consists

1



2

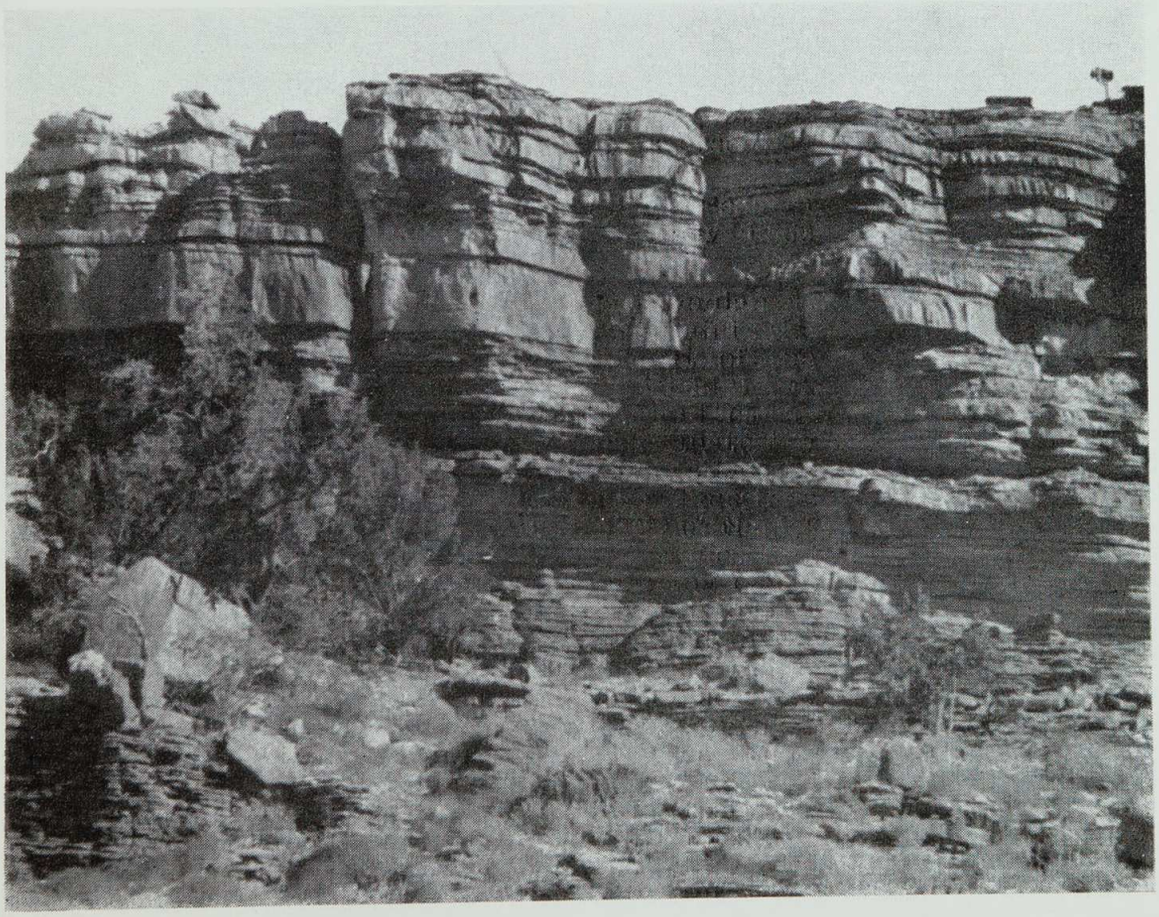


PLATE I

1. The eastern side of the Barker Gorge east of the Barker Fault, showing the Upper Devonian Napier Formation predominantly layered clastics with small bioherm growths on the upper right of the picture.
2. Upper Devonian Napier Formation layered calcarenites in the Wagon Pass, Napier Range.

mostly of grey massive and bedded calcarenites and sandy calcarenites with bioherms. This portion of the sequence is fossiliferous and contains crinoids and spiriferids. In the section of the Napier Range 4 miles west-north-west of Napier Downs Station the Napier Formation is 2,263 feet thick and 8 miles north-west of the same station it is 2,281 feet thick. The average thickness of Napier Formation in the western part of the area is more than 1,500 feet.

The thickness of Napier Formation measured in Wombarella Gap does not differ much from that of 700 feet at Carpenter Gap 20 miles to the south-east. (Guppy *et al.* 1958, p. 39).

The Napier Formation in the eastern part of the Napier Range is considerably thinner than in the western portion of the area. Over the whole area, then, the Napier Formation varies in thickness from 682 feet to 1,500 feet and more.

Van Emmerick Conglomerate and Behn Conglomerate.—The Van Emmerick Conglomerate and Behn Conglomerate are lateral facies variations of the Napier Formation. They interfinger with, as well as replace, the shallow water marine facies. The Van Emmerick Conglomerate is exposed in Van Emmerick Range in the west of the area and consists of brownish grey conglomerate containing some lenses of fine-to medium-grained brown flaggy sandstone. These lenses average from 11 inches to 13 inches in thickness. The conglomerate is formed of well rounded boulders, cobbles, and pebbles of quartzite and granite, with some boulders also of schist and quartz. Quartzite boulders range from 1 foot to 1 foot 9 inches in diameter, and granite boulders from 6 inches to 3 feet.

The Behn Conglomerate crops out at Mt. Behn in the eastern part of the area and is lithologically similar to the Van Emmerick Conglomerate.

Guppy *et al.* (1958 p. 40) suggest that approximately 1,000 feet of these sediments have been preserved. The conglomerates represent torrential fanglomerates which interfinger seawards with the sediments of the Napier Formation.

Middle Devonian

Pillara Formation.—Only remnants are left of the Middle to early Upper Devonian Pillara Formation in the western part of the area mapped. Middle Devonian sediments crop out in the Napier Range in the eastern portion of Wagon Pass, at Windjana Gorge, north-west of Windjana Gorge, and north-east of Fairfield homestead.

An outcropping section of Pillara Formation 742 feet thick has been measured in the Napier Range 8 miles north-west of Napier Downs Station. The formation there is sandy and is composed of brown calcareous sandstone with intercalations from 14 to 36 feet thick of grey and pinkish sandy calcarenite. Thicknesses of 5 to 132 feet of brownish calcareous sandstone were measured in this section. Guppy *et al.* (1958, p. 22) have distinguished a basal arkosic sandstone facies which is well expressed also in the Napier Range. This quartzose clastic material is found in the northern part of Windjana Gorge and it forms the lower portion of the section measured 8 miles north-west of Napier Downs homestead. McWhae *et al.* (1958, p. 37) write that "the basal calcarenites and quartz greywackes have their maximum development, which is in excess of 250 feet, along the Napier Range."

Lower Proterozoic and Archaeozoic

The Lower Proterozoic and Archaeozoic Lamboo Complex of schist, gneiss, slate, phyllite, granite and granitized sediments, forms the basement and is exposed to the north-east of the Napier Range.

Structural Geology

Folding

The middle of the western portion of the area is occupied by a syncline whose axis trends north-west. This axis is clearly expressed to the north-west of Barker River, where north-westerly dips were encountered along Station Creek in the calcarenites belonging to the Laurel Beds, and in the sandstone outcrop of the Grant Formation 13 miles north-east of the south-western corner of the area mapped.

The south-western corner is occupied by the north-eastern slopes of the buried ridge which is the north-western continuation of the Oscar Range. Indicating this are the north-easterly dips observed in the Grant Formation sandstones of the Hawkstone Peak area. These dips are between 7° and 8°. South-westerly dips occur in the middle and eastern portions of the area. An exceptionally steep dip, caused by the north-north-easterly trending Wombarella Fault, was observed in the Fairfield Beds 4½ miles south-south-east of Napier Downs homestead.

The Laurel Beds are folded on a small scale, for example north-east of Mt. Percy, and at Station Creek. This folding can be accounted for by the nature of the strata involved, shales with thin intercalations of calcarenite, which are highly incompetent and can be easily subjected to slumping, crumpling and folding. Guppy *et al.* (1958, p. 41) state that "The beds show complex folding and faulting within the strata; this is in contrast to the underlying Upper Devonian, which dips south-west into the basin at 15°. The local complex folding is probably due to slumping." The above-mentioned structural feature is a very characteristic one for the Laurel Beds and it is always encountered where these beds are exposed.

Faulting

Pronounced faulting is expressed in the area under consideration. The main sets of faults more or less parallel the Napier Range. They occur in the Napier Range itself as well as to the south-west of it, and trend N.47°W. and N.60°W. Other sets of faults in the Napier Range trend N.35°W. and sets of faults and large fractures trending east-west; north-south; N.7°E.; N.20°E. and N.38°E. also occur there. The small Wombarella Fault, 4 miles south-east of Napier Downs, cuts the Napier Range at Wombarella Gap and continues on towards the south-west where it is expressed in Fairfield Beds. Very small horizontal as well as vertical displacements have taken place along this fault which has moved west block north-east and down, east block south-west and up.

Other faults with north-easterly trend cut the area and together with the Wombarella Fault, form a group with trend N.20°E. to N.30°E. The Barker Fault with a trend of N.25°E. belongs to this type. It cuts the Napier Range across the Barker River Gorge and there are prominent fractures associated with it in Napier Formation calcarenites and calcareous sandstones. Horizontal movements totalling one mile have occurred along this fault, and the movement is evidenced by tension fracturing in the gorge. Vertical movements have also taken place. The relative directions are: west block south-west and down, and east block north-east and up.

The Barker Fault continues from the Napier Range toward the south-west, passing to the west of the 67-Mile Bore, 19 miles south-west of Napier Downs. The bore is located on the upthrown side of the fault, and this explains in part why only approximately 2,500 feet of sedimentary strata were penetrated. The 67-Mile Bore is also on the north-western continuation of the Oscar Range buried ridge, which to the west of the bore is cut by the south-western continuation of the Barker Fault. It is evident that conditions favour a shallow basement in the vicinity of the bore.

Another fault belonging to the same set of north-easterly trending faults, and having a trend of N.30°E., was found at Mt. Percy. Evidence of this fault is displayed in the Grant Formation north-east of Mt. Percy. The fault crosses the Station Creek Fault, and leucite-rich intrusives at Mt. Percy have used this junction as a point of weakness. It should be mentioned here that the Station Creek Fault is breaking at this cross-point and changes direction beyond.

To the N.47°W. set belongs the fault in the Fairfield Beds, at Station Creek 2 miles west-north-west of Old Napier Ruins, which is herein named the Old Napier Fault. The south-eastern continuation of the Old Napier Fault has been found transecting the Fairfield Beds 5 miles south-south-east of Napier Downs. The Old Napier Fault is displaced by the Barker Fault. Its further continuation towards the south-east cannot be followed because of the thick alluvial cover.

The largest of the faults belonging to this north-westerly trending set is the Station Creek Fault, expressed at Station Creek 6 miles west-south-west of Old Napier Ruins. This fault continues on towards the south-east, where leucite-rich intrusives have used it as a line of weakness. The point where the Barker River joins the Lennard River is on the line of the Station Creek Fault. It is a well known and interesting fact that topographic features such as this coincide with faulting. Dragging of strata along the Station Creek Fault occurs at Station Creek, 6 miles west-south-west of Old Napier Ruins, and at Mt. Percy. At Station Creek Laurel Beds and Grant Formation are involved. Hard, grey calcarenites of the Laurel Beds are dragged along the north-side of the fault and show that the north-east block has moved to the north-west. Fine-grained, brown, flaggy, shaley sandstones belonging to the Permian Grant Formation or to up-dragged, underlying, Upper Carboniferous Anderson Formation, are turned into a vertical position. Grant Formation sandstones are dragged along the fault at Mt. Percy, where the movement of strata indicates a south-easterly horizontal component of the south-west block. Here at Mt. Percy, the Station Creek Fault changes its trend, continuing further to the south-east with trend N.60°W. in the north-western end of the Oscar Range where it dips 79° N.E. The south-western block continues to be down-thrown as it is between Station Creek and Mt. Percy.

Several large tension fractures trending N.55°E. were encountered on the north-western end of Oscar Range. The author has found that this area is cut by several faults, all trending more or less parallel with the Oscar Range. As a result of this faulting a small graben is developed on the crest of the range. In the author's opinion, this is due to crustal sagging after the leucitic intrusives found release at the weak point where faults intersect at Mt. Percy.

Fracturing

Pronounced fracturing is connected with the strong faulting in the mapped area. The most favourable rocks, which were brittle and subjected to intensive fracturing, were the Grant Formation sandstones and the Napier Formation calcarenites. Tension fractures accompany the faults. A large tension fracture forms the "tunnel" in the Napier Formation calcarenites 5½ miles south-east of Fairfield homestead. This tension fracture trends N.50°E., dips 60° S.E., and is associated with faulting in the Napier Range trending approximately parallel with the range.

References

Guppy, D. J., Lindner, A. W. Rattigan, J. H., and Casey, J. N. (1958).—The geology of the Fitzroy Basin, Western Australia. *Bull. Bur. Miner. Resour. Aust.* **36**.

McWhae, J. R. H., Playford, P. E., Lindner, A. W., Glenister, B. F., and Balme, B. E. (1958).—The stratigraphy of Western Australia *J. Geol. Soc. Aust.* 4(2): 1-161.